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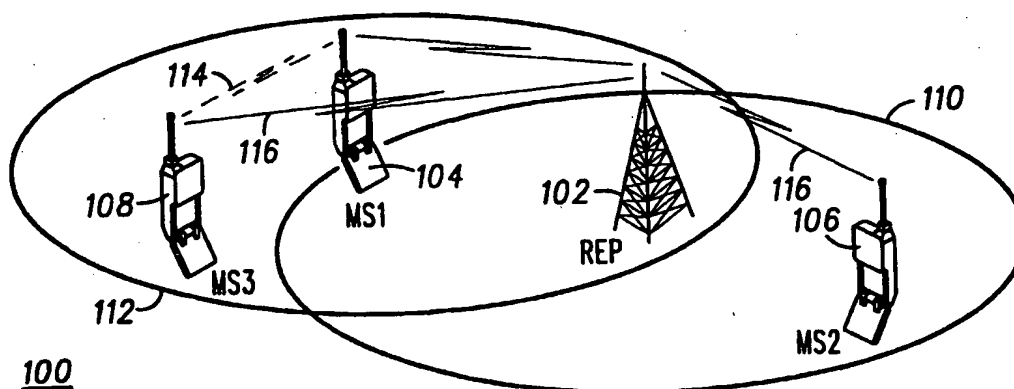
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(54) Title: **RADIO COMMUNICATION SYSTEM COMPRISING COMMUNICATION UNITS THAT COMMUNICATE EITHER DIRECTLY OR VIA AN INTERMEDIATE NODE**



(57) Abstract: A communication system (100) includes a plurality of communication units (104-108) that communicate either directly or via an intermediary communication unit (102). A first communication unit (108) receives directly (114) a call set-up request from a second communication unit (104), wherein the call set-up request includes an indication that the call is to be set-up via the intermediary communication unit (102). The first (308) for determining that a signal quality from the second communication unit is or will be better than a signal quality from the intermediary communication unit (102). In response to such a determination the first communication unit (108) joins the call with the second communication unit (104) directly. A communication unit and method of setting up a call are also provided.

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RADIO COMMUNICATION SYSTEM COMPRISING COMMUNICATION UNITS THAT
COMMUNICATE EITHER DIRECTLY OR VIA AN INTERMEDIATE NODE

Field of the Invention

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This invention relates to a radio communication system, a communication unit and a method of communication. In particular it relates to the selection of a communication resource in a mobile communication system. The invention
10 is applicable to, but not limited to, a subscriber unit operable to provide a radio communication link between itself and a second subscriber unit. The method is operable to establish a call set-up.

15 Background of the Invention

Systems for radio communication between subscribers are distinguished over fixed communication systems, such as the public switched telephone networks (PSTN),
20 principally in that subscriber communications units may move between communication service areas and providers and in doing so encounter varying radio propagation environments. Therefore the quality of a communication link to/from a subscriber unit varies as the subscriber
25 unit changes its location.

The subscriber units are typically either vehicular-mounted 'mobile' or 'hand-portable' radio or cellular units. Henceforth, the term mobile station (MS) will be
30 used to embrace all such subscriber communication units.

Wireless communication systems, for example cellular telephony or private mobile radio communication systems, typically provide for radio telecommunication links to be arranged between a plurality of subscriber units. There
5 are typically two methods of communicating between MSs. A first mode is a direct communication between two MSs. A second mode uses an intermediary station to forward the communication. The intermediary station may comprise a base transceiver station (BTS) connected to the
10 communication system infrastructure. A BTS is generally considered an "intelligent" terminal, as it has the processing and control capability to influence a substantial amount of the communication traffic passing through it.
15
A further intermediary station is a radio repeater station, which performs a minimal amount of processing in receiving a communication from a first MS and re-transmitting the received communication to at least one
20 second MS. As a repeater station has little control over the communication passing through it, it is often termed a "dummy" terminal.

The communication link from a BTS or a repeater to a MS
25 is generally referred to as a down-link communication channel. Conversely, the communication link from a MS to a BTS or a Repeater is generally referred to as an up-link communication channel.

30 Multiple access techniques permit simultaneous communication links to be set-up to/from several MSs over

a plurality of communications channels. In some cases, one or more channels are used for carrying traffic (e.g. information such as speech sent from user to user) whilst one or more other channels (which may be logical or
5 dedicated channels) are used for transferring system control information. Examples of multiple access techniques include: frequency division multiple access (FDMA), time division multiplexing/ multiple access (TDM, TDMA) and code division multiple access (CDMA).

10 In a wireless private mobile radio (PMR) communication system, it is known, as noted earlier, that a MS may be able to communicate in a direct communication link with at least one other MS, especially where one or both of
15 the MSs are outside a dedicated network coverage area. Such a communication mode is generally referred to as Direct Mode Operation (DMO). This term is in contrast to Trunked Mode Operation (TMO) that enables the MS to work within a network coverage, with communications routed via
20 one or more base transceivers. When a MS operates in DMO, communications do not pass through any base transceiver or other fixed 'intelligent' system hardware and there is no system controller and therefore no centralised timing synchronisation or power control to help minimise
25 interference between channels.

DMO is similar in principle to the back-to-back operation of conventional half-duplex radio schemes used by many existing private mobile radio (PMR) systems such as that
30 of the emergency services. DMO communications are

limited in range due to limitations placed on the MS,
such as maximum transmit power or channel conditions.

When operating in DMO, MSs communicate over dedicated
5 frequencies. A MS operating in DMO may select a
dedicated frequency or the MS may scan the available
dedicated frequencies to find an available frequency
based on signal strength measurements. In some DMO
environments there may be a pool of communication
10 channels available.

The selection of a particular frequency by a MS
especially when operating in DMO is generally dependent
upon whether the measured signal strength exceeds a
15 fixed, acceptable-communication threshold. Used methods
of selecting and scanning frequencies are inefficient
when there are a large numbers of users in a DMO system,
owing to the unstructured nature and consequential high
level of interference associated with such DMO
20 communications.

Furthermore, the received signal level can vary
sporadically owing to the changing propagation
conditions. In addition, interference is dependent upon
25 the number of users and the number of users varies from
time to time on a system.

In radio communication systems operating without a fixed
network control, such as DMO, communication repeaters
30 have been used in the prior art to extend the
communication range of MS to MS communications. For

instance, a first MS may transmit to a repeater for re-transmission, after minimal decoding and error correction processing, to a second MS.

- 5 Such a communication is particularly advantageous if the second MS would have been out of transmitting range of the first MS without the use of the repeater. A direct mode repeater thus provides a service for direct mode radios wishing to communicate over an enlarged direct
10 mode coverage area. Direct mode repeaters may operate using either a single frequency or two or more frequencies.

- There is no known mechanism in place for MSs operating in
15 DMO to optimise the use of the direct mode resources. As a consequence, there are no signalling schemes available for a direct mode repeater to form any type of a broadcast signal during periods of channel inactivity and/or during periods of communications. Lack of
20 available signalling information is likely to result in some calls being jammed or never even set up. In many uses, such as in police or public safety communications, such an unreliable communication link is unacceptable.

- 25 A known procedure for operation via a DMO repeater has been defined by the European Telecommunication Standards Institute (ETSI) in the Terrestrial Trunked Radio (TETRA) standard in ETS-300-396-4.

- 30 According to the TETRA DMO standard, all MSs working through a DMO repeater station will monitor down-link

Another scenario might be that at least some members of the talk group may be able to receive both the calling MS and the repeater's re-transmitted signal, but a direct
5 signal from the calling MS may be received at a much higher quality than the re-transmitted signal from the repeater. According to the known procedures such MSS are forced to receive calls at the lower quality via the repeater.

10

In summary, standard DMO communication, via a repeater, imposes potentially unnecessary limitations on the quality of a communication link in certain operational scenarios. The stipulation of a DMO communication to
15 operate via a repeater, at all times, will often lead to sub-optimal call quality.

Thus there currently exists a need to provide an improved communication system, a communication unit and method of
20 setting up a call wherein the aforementioned disadvantages may at least be alleviated.

Statement of Invention

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In accordance with the present invention in a first aspect there is provided a radio communication system comprising a plurality of communication units that are operable to communicate either directly or via an
30 intermediary communicating unit, the communication system being characterised by at least a first communication

transmissions from the repeater in order to receive calls via the repeater. The down-link transmission is basically a repeated and delayed version of the corresponding up-link transmission to the repeater.

5

In known DMO procedures a calling MS is instructed, either by pre-programmed information or by detection of the repeater's presence signal, to address the repeater when attempting to set-up a call and subsequently
10 transmit to a Talk Group or other individual MS. Called MSs know, either by pre-programming or by detection of the repeater's presence signal, to monitor only the downlink repeater link searching for their own individual or group address. Once they have received a re-
15 transmission signal from the repeater, specifying their individual or group address, they can decide whether or not to join the individual or group-call.

However, the inventors of the present invention have
20 recognised that such a call set-up mechanism is inefficient in certain operational scenarios. First, let us assume that a first MS is attempting to set up a group-call, via a repeater, with a second and third MS. The second MS is within range of the repeater, but the
25 third MS is determined to be outside the coverage range of the repeater but within coverage range of a direct transmission from the first MS. Hence, although the third MS can receive a communication direct from the first MS, the third MS will not be included in the group-
30 call, as it will not receive any re-transmitted signal from the repeater.

unit of the plurality of communicating units being operable to receive directly a call set-up request from at least a second communication unit of the plurality of communicating units, wherein the call set-up request
5 includes an indication that the call is to be or may be set-up via the intermediary communication unit, and said first communication unit includes a signal processor for determining that a signal quality of a signal received directly from the first communication unit is or will be
10 better than a signal quality of a re-transmitted signal from the intermediary communication unit, and in response to such a determination the first communication unit is operable to participate in the call with the second communication unit directly.

15

In accordance with the present invention in a second aspect there is provided a radio communication unit capable of communicating with a second communication unit either directly or via an intermediary communication
20 unit, the first mentioned radio communication unit being characterised by:

a receiver for receiving directly a call set-up request from the second communication unit, wherein the call set-up request includes an indication that the call
25 is to be or may be set-up via the intermediary communication unit,

a signal processor operably coupled to the receiver for determining that a signal quality of a signal received directly from the second communication unit is
30 or will be better than a signal quality of a re-

transmitted signal from the intermediary communication unit,

wherein the radio communications unit is operable in response to such a determination by its signal processor
5 to participate in the call with the second communication unit directly.

In accordance with the present invention in a third aspect there is provided a method of setting up a call by
10 radio communication between a communication unit of a calling party and a communication unit of at least one receiving party, the method being characterised by the steps carried out by the communication unit of a receiving party:

15 receiving a radio call setup request transmission from a communication unit of a calling party, wherein the call set-up request includes an indication that the call is to be or may be set-up via an intermediary communication unit; and

20 determining that a signal quality of a signal received directly from the communication unit of the calling party is or will be better than a signal quality of a re-transmitted signal via the intermediary communication unit; and

25 participating in the call with the communication unit of the calling party directly.

The intermediary unit desirably comprises a repeater. The repeater as in the prior art can for its "uplink" and
30 "downlink" channels (i.e. channels for inward and outward signals) use either single frequency or a pair of

frequencies. In use of the invention, where two frequency channels are employed, the called MS(s) is (are) desirably operable to monitor both frequencies for sufficient time and regularity so that a call setup transmission of both a calling master MS and the repeater are detectable, especially if only one of these units is within range. If the call setup transmission from the calling MS can be received and decoded properly, the receiving MS needs to be able to tune its receiver frequency to each of the two channels in order to perform the comparative link measurements.

In the prior art, the receiving MS ignores a signal received directly from the calling MS because only the signal sent to the repeater contains an address identifier. In use of the invention, desirably the signal sent by the calling MS, e.g. especially the call set-up signal, includes an address identifier of both the repeater and the target receiving MS(s) so that the receiving MS(s), when within range, may identify, decode and carry out measurements on the signal received directly from the calling MS as well as that from the repeater.

Further features of the system, communication unit and method according to the invention are as defined in the accompanying claims.

Beneficially, the communication system, unit and method according to the invention provide at least the following advantages:

- 5 (i) A receiving communication unit (MS) is able to decide on a preferred mechanism to join a call between two or more parties, via a repeater or by receiving signals directly from a communication unit of a calling party, based on measurements of the respective link
- 10 qualities.
- (ii) A receiving MS is able to join a communication in circumstances where the repeater would not in the prior art facilitate a communication to the calling MS,
- 15 for example where the receiving MS or calling MS is outside the repeater coverage range, or in the case where a repeater re-transmission will have a poorer quality than a direct MS communication.
- 20 (iii) The delay (call set-up and voice delay) introduced when setting up a direct communication link if selected to be a preferred link is less than the overall delay when operating through the repeater.
- 25 Thus a communication system, a communication unit and communication unit are provided by the invention whereby the disadvantages described earlier with reference to prior art arrangements are substantially alleviated and improved communication is facilitated.

Exemplary embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:

5 Brief Description of the Drawings

FIG. 1 is a schematic block diagram of a direct mode radio communication system adapted to support the various inventive concepts of a preferred embodiment of the
10 present invention;

FIG. 2 is a timing diagram illustrating a known timing process that can be implemented in the direct mode communication system of FIG. 1 to facilitate the
15 inventive concepts of a preferred embodiment of the invention;

FIG. 3 is a simplified block circuit diagram of a subscriber unit adapted to support the inventive concepts
20 of the preferred embodiments of the present invention; and

FIG. 4 is a flowchart of the decision making process for performing a call set-up in accordance with a preferred
25 embodiment of the invention.

Description of embodiments of the invention

30 In accordance with an embodiment of the invention, MSs operating in DMO use both up-link and down-link (via a

Repeater) aspects of a direct mode call set-up transmission, in order to assess whether they wish to join a call directly or via the Repeater.

- 5 In particular, the inventors of the present invention have recognised the opportunity, and associated benefits thereby provided, to monitor up-link as well as down-link transmissions in a call set-up procedure in a DMO communication system.

10

Turning first to FIG. 1, a typical DMO communication scenario is shown. The DMO communication system 100 includes a Repeater 102 facilitating communications between a plurality of MSs (104, 106, 108). Repeater 102
15 effectively provides a communication coverage range as shown by area 110. In practice, many MSs will be able to communicate at any instant in time, with three MSs shown in FIG. 1 for clarity purposes only.

- 20 In operation, MS-1 wishes to set up a group-call with MS-2 106 and MS-3 108. As can be seen, MS-2 106 is within the communication coverage range of Repeater 102, whilst MS-3 108 is not. However, MS-3 108 is within direct communication coverage range of MS-1 104.

25

In an embodiment of the invention, for example with regard to the TETRA standard, MS-1 104 transmits a group-call set-up request 112 to Repeater 102 on an "up-link (master-link) timeslot". MS-3 108 receives this group-
30 call request by a direct communication link 114.

The Repeater 102 re-transmits the group-call set-up request to another MS, or group of MSs, on a "down-link (slave-link) timeslot" 116, for example to MS-2 106 and MS-3 108. As MS-3 108 is out of communication range of Repeater 102, MS-3 108 fails to receive the re-transmission of the group-call set-up request 116.

At the same time, MS-2 106 is out of direct communication range with MS-1 104, and only receives the re-transmission of the group-call set-up request 116, from the Repeater 102. The Repeater 102 specified within the TETRA standard is regenerative, i.e. it decodes and re-encodes received speech and signaling bursts which it receives (one slot's worth each time), to improve the overall link performance.

In accordance with an embodiment of the invention, MS-3 108 has been adapted to decode call set-up messages received directly from MS-1 104, in addition to any call set-up message re-transmitted from Repeater 102. Both MS-2 106 and MS-3 108 will recognise that the call is to be established via Repeater 102 due to the inclusion of a Repeater address in the call set-up request transmitted by MS-1 104.

MS-2 106 and MS-3 108 will independently perform link measurements of the direct communication link 114 with MS-1 104 (if it exists) using the group-call set-up transmission request from MS-1 104 on the master-link 112. Preferably, such link quality measurements may include any of the following: received signal strength

indication (RSSI), bit-error-rate (BER), message-error-rate (MER), carrier to interference (C/I), or any other known quality indicia.

- 5 In addition, whilst the Repeater 102 re-transmits the group-call set-up message 116, as initially transmitted by MS-1 104, to both MS-2 106 and MS-3 108, MS-2 106 and MS-3 108 will perform the same link measurement on the Repeater's re-transmission call request signal 116 (if
10 the signal can be successfully received).

Based on the link measurements of both the direct group-call set-up request transmission of master MS-1 104 and the Repeater's 102 re-transmitted group-call set-up
15 request signal, MS-2 106 and MS-3 108 will independently decide whether to join the group call by receiving traffic communication direct from MS-1 104, or via the Repeater 102.

- 20 If a call set-up request transmission from either the master MS-1 104 or the Repeater 102 cannot be successfully received, the decision becomes trivial, as in the present case. In such a situation, MS-2 106 will join the group-call via the Repeater 102 and MS-3 108
25 will be able to join the group-call, by receiving and processing direct communication from MS-1 104.

However, if both the master-link 114 and the slave-link 116 can be successfully received and assessed, the
30 decision is not trivial. In this case, MS-2 106 and/or MS-3 108 would make a determination on whether to join

the group-call directly with MS-1 104 or via the Repeater 102.

Generally, the decision would be to join the call via
5 Repeater 102, so that any replies to MS-1 104 can also be heard and received by other MS. When the slave MS, for example MS-2 106, replies to the calling MS, the slave MS will always respond through the Repeater 102.

10 If the call request by MS-1 104 is for a broadcast communication, MS-2 106 and/or MS-3 108 would not need to make, or hear, any replies to the broadcast transmission from MS-1 104. In this case, the selection of the
15 individual link's signal quality measurement.

It is within the contemplation of the invention that the inventive concepts described herein are equally applicable to group (point-to-multipoint) call set-up
20 requests or individual (point-to-point) call set-up requests.

A known method of setting up a call in a DMO channel is illustrated in FIG. 2. In FIG. 2, a MS (say, MS-1 104 of
25 FIG. 1) initiates a call and establishes the channel synchronization by transmitting a sequence of call set-up messages to a Repeater (say, Repeater 102 of FIG. 1). On setting up a call the MS automatically assumes the role as "master", with the communication link to the Repeater
30 being the master-link.

The call set-up arrangement is described with reference to the TETRA timing structure, which uses a TDMA access protocol 200. The timing structure is arranged in super-frames, with each super-frame comprising eighteen
5 (rolling) time-frames. Time-frames seventeen to three 202-210 are shown with each divided into four time-slots 214-220, shown in relation to different time-frames for clarity purposes only.

10 The two-way communication link is divided into two parts:
(i) an up-link (master-link) 222 where the MS transmits in "master-Rep" time-slots 226 to the Repeater and receives messages in "Rep-master" time-slots 228 from the Repeater; and

15 (ii) a down-link (slave-link) 224 where the Repeater relays transmitted information from the transmitting MS in "Rep-slave" time-slots 230, to at least one other MS and is able to receive responses from the at least one other MS in "slave-Rep" time-slots 232.

20

In the example shown in FIG. 2, seven synchronization bursts ("su") are sent in master-Rep time-slots 226 in time-frame seventeen 202 and time-frame eighteen 204 of the master link 222. The synchronization bursts are
25 received by the Repeater and re-transmitted ("su'") in Rep-slave time-slots 230 by the repeater on the slave-link. Note that due to propagation delays, the re-transmitted synchronization bursts "su'" are delayed by one time-frame compared to the initially transmitted
30 synchronization bursts "su".

In this example, synchronisation bursts are transmitted in two frames giving up to a total of eight bursts, although the receiver needs only to receive just one of these bursts.

5

The master MS may then transmit traffic ("tc") information in the next available time-frame, which in this example is the first time-slot of the third time-frame 210 of the master link.

10

It is proposed that a receiving MS(s) will decode the "su" call setup messages received directly from MS-1, namely at least one of the seven synchronisation bursts in the "master-Rep" 226 series of time-slots. Receiving MS(s) will recognise that the call is to be established via Repeater due to the inclusion of the Repeater address in the call setup message.

Receiving MS(s) will independently perform link measurements between itself and the calling (master) MS using the "su" call setup transmission of the (master) MS.

Receiving MS(s) will tune to the "Rep-slave" 230 series of time slots on the slave-link channel 224 and also receive at least one "su'" call set-up request re-transmitted from the Repeater.

Based on the link measurements of both the master MS's direct "su" call set-up request and the Repeater's re-transmitted "su'" call set-up request, the receiving

MS(s) decides whether to join the call by receiving traffic communication direct from the master MS, or via the Repeater.

- 5 The Repeater can use either single frequency for "uplink" and "downlink" channels or a pair of frequencies. If a pair of frequencies are used, all receiving MS(s) will monitor both frequencies at a sufficient rate such that they can correctly decode both a call set-up request from
- 10 a master MS and the Repeater's re-transmitted call set-up request. This is particularly advantageous if only one of the master MS or Repeater is within its communication range.
- 15 If the master MS call set-up transmission can be received and decoded properly, a receiving MS may have to tune their frequency synthesizer to receive the Repeater re-transmission signals in order to perform both link measurements.
- 20 The invention is described with reference to the TETRA DMO Repeater standard, although it is within the contemplation of the invention that the inventive concepts described herein apply to any fixed, wireless or
- 25 wireless DMO communication system.

It is also within the contemplation of the invention that any number of alternative timing configurations would benefit from the inventive concepts described herein.

Turning now to FIG. 3, a block diagram of a MS 300, adapted to support the inventive concepts of the preferred embodiments of the present invention, is shown. The MS 300 contains an antenna 302 preferably coupled to
5 a duplex filter or circulator 304 that provides isolation between receive and transmit chains within the MS 300.

The receiver chain includes scanning receiver front-end circuitry 306 (effectively providing reception, filtering
10 and intermediate or base-band frequency conversion). The scanning front-end circuit 306 is serially coupled to a signal processing function 308.

In accordance with a preferred embodiment of the
15 invention, the receiver chain has been adapted to receive both call set-up request transmissions on the master-link transmitted by the calling MS, as well as the re-transmitted call set-up request transmissions from the Repeater on the slave-link.

20 The scanning front-end receiver 306 has been adapted, in accordance with the present invention, to scan the appropriate frequencies and if necessary, say for paired frequency operation, switch between frequencies to decode
25 signals transmitted on both a master-link and a slave-link.

The controller 314 may calculate receive bit-error-rate (BER) or frame-error-rate (FER) or similar link-quality
30 measure data from recovered information via a received signal strength indication (RSSI) 312 function. The RSSI

312 function is operably coupled to the scanning front-end circuit 306. The memory device 316 stores a wide array of MS-specific data, such as decoding/encoding functions and the like, as well as link quality measurement information to enable an optimal communication link to be selected.

A timer 318 is operably coupled to the controller 314 to control the timing of operations, namely the transmission or reception of time-dependent signals, within the MS 300. In the context of the preferred embodiment of the present invention, timer 318 will be used to synchronize the receiving MS to the timing initiated by the calling MS.

Furthermore, once the timing format has been initiated, the timer 318 is used by the controller to select the appropriate master-link and slave-link channels and time-slots for tuning to.

As known in the art, an output from the signal processing function is typically provided to a suitable output device 310, such as a speaker or visual display unit (VDU).

As regards the transmit chain, this essentially includes an input device 120, such as a microphone, coupled in series through transmitter/modulation circuitry 122 and a power amplifier 124. The transmitter/modulation circuitry 122 and the power amplifier 124 are operationally responsive to the controller, with an

output from the power amplifier coupled to the duplex filter or circulator 104, as known in the art.

Of course, the various components within the MS 300 can
5 be realised in discrete or integrated component form, with an ultimate structure therefore being merely an arbitrary selection.

In operation, upon power-on of MS 300, the MS 300 will
10 search (scan) for all call set-up requests where it may be addressed. Once an appropriate call set-up request has been received, from a calling MS setting up the master-link, the MS 300 will perform a signal quality measurement. The MS 300 will then switch to the slave-
15 link to perform a similar signal quality measurement on the Repeater's re-transmitted call set-up request.

The signal processor function 308 will then determine which communication link will best suit the particular
20 MS, and inform the controller 314 of the fact. The controller 314 will then organize the operation of the MS 300 such that an acceptable communication link to the calling MS is established.

25 Turning now to FIG. 4, a flowchart of the decision making process for a call set-up is shown, in accordance with a preferred embodiment of the invention.

The method includes the steps of a MS monitoring any
30 appropriate frequencies searching for a call set-up request, as shown in step 400. Once a call set-up

request has been detected and decoded, as in step 402, the MS determines the type of call, as shown in step 404.

- If the call-type is a master transmit call, without a
5 repeater address, the MS determines that a regular DMO call procedure will be followed, as shown in step 408. If the call-type is a Repeater's re-transmission of a call set-up request on a slave-link, the MS determines that a regular DMO call via a Repeater procedure will be
10 followed, as shown in step 406. In this case, it is likely that the receiving MS has not heard the calling MS's call set-up request, and is therefore only able to join the call via the Repeater.
- 15 If the call-type is not one of the above call-types, the MS performs at least one signal quality measurement on the master link, as in step 410. The MS then switches to the slave link, if appropriate, and waits for the Repeater's re-transmitted call set-up request
20 transmission, as in step 412. The MS then performs at least one signal quality measurement on the Repeater's re-transmitted call set-up request transmission, as shown in step 414.
- 25 The two link quality measurements are then compared, as shown in step 416. If the master-link is determined to be of a better quality than the slave-link, the MS joins the DMO call by tuning into the master-link, as in step 420. If the slave-link is determined to be of a better
30 quality than the master-link, the MS joins the DMO call by tuning into the slave-link, as in step 418.

It is within the contemplation of the invention that the re-transmission of the call set-up request from the repeater may encompass any transmission from the repeater
5 that indicates a request has been made.

In this manner, the MS has selected its optimal method of communicating in the call, without being constrained to purely receiving a Repeater's relayed transmissions.

10

It is within the contemplation of the invention that a receiving MS may not need to perform a signal quality measurement on the master-link, if it knows that it is out of range of the Repeater station. In such a
15 situation, the only option to join a subsequent call is via a direct communication with the calling MS and, as such, no signal quality measurement needs to be performed.

20

Claims

1. A communication system comprising a plurality of
5 radio communication units that are operable to
communicate with each other either directly or via an
intermediary communicating unit, the communication system
being characterised by at least a first communication
10 unit of the plurality of communicating units being
operable to receive directly a call set-up request from
at least a second communication unit of the plurality of
communicating units, wherein the call set-up request
includes an indication that the call is to be or may be
15 set-up via the intermediary communication unit, and said
first communication unit includes a signal processor for
determining that a signal quality of a signal received
directly from the first communication unit is or will be
better than a signal quality of a re-transmitted signal
20 from the intermediary communication unit, and in response
to such a determination the first communication unit is
operable to participate in the call with the second
communication unit directly.

2. A communication system according to claim 1, wherein
25 said first communication unit includes signal quality
determination means operably coupled to the signal
processor for measuring a signal quality of the call set-
up request transmitted by the second communication unit
in order to determine that a call quality when
30 participating in the call directly with the second
communication unit is or will be acceptable.

3. A communication system according to claim 1 or claim 2 and wherein the first communication unit comprises: monitoring means operably coupled to the signal processor, for monitoring both a communication link of the call set-up request and a communication link of a re-transmitted call set-up request as transmitted by the intermediary communication unit, the monitoring means being operably coupled to said signal quality measuring means for measuring a signal quality of the call setup request and a signal quality of the re-transmitted call set-up request and comparison means operably coupled to the measuring means for comparing the respective measured signal qualities and in response to the comparison determining whether to participate in the call directly with the second communication unit or via the intermediary communication unit.

4. A communication system according to claim 3 and wherein the signal quality measurement includes measurement of any one or more of the following: received signal strength indication, bit-error-rate, message-error-rate, carrier to interference, and other known signal quality indicia.

5. A communication system according to any one of the preceding claims, wherein the communication system is a radio communication system capable of operation in a direct mode, the plurality of communication units are radio units capable of direct mode communication and the

intermediary communication unit is a radio communication repeater.

6. A radio communication unit capable of communicating
5 with a second communication unit either directly or via
an intermediary communication unit in a system according
to claim 1, the first mentioned radio communication unit
being characterised by:

a receiver for receiving directly a call set-up
10 request from the second communication unit, wherein the
call set-up request includes an indication that the call
is to be or may be set-up via the intermediary
communication unit,

a signal processor operably coupled to the receiver
15 for determining that a signal quality of a signal
received directly from the second communication unit is
or will be better than a signal quality of a re-
transmitted signal from the intermediary communication
unit,

20 wherein the radio communications unit is operable in
response to such a determination by its signal processor
to participate in the call with the second communication
unit directly.

- 25 7. A communication unit according to claim 6 which is
further characterised by:

signal quality determination means, operably coupled
to the signal processor, for measuring a signal quality
of the call set-up request transmitted by the second
30 communication unit in order to determine that a call

quality when participating in the call directly with the second communication unit is or will be acceptable.

8. A communication unit according to claim 7 which is
5 further characterised by:

monitoring means operably coupled to the signal processor, and the signal quality measuring means, for monitoring both a communication link of the call setup request and a communication link of a re-transmitted call
10 set-up request as transmitted by the intermediary communication unit, the signal quality measuring means being operable to measure a signal quality of the call setup request and re-transmitted call set-up request, and

comparison means operably coupled to the measuring
15 means for comparing the measured signal qualities and in response to the comparison the signal processor determines whether to participate in the call directly with the second communication unit or via the intermediary communication unit.

20

9. A communication unit according to claim 8, wherein the signal quality measurement means is operable to measure any one or more of the following: received
signal strength indication, bit-error-rate, message-
25 error-rate, carrier to interference and other known signal quality indicia.

10. A communication unit according to any one of claims 6 to 9 and which comprises a mobile station capable of
30 operating in a direct mode radio communication system.

11. A communication unit according to claim 10 and wherein the mobile station is also capable of operating alternatively in a trunked mode radio communication system.

5

12. A communication unit according to any one of claims 6 to 11 and which as a receiving communication unit is operable to receive signals from a calling communication unit directly in a first frequency channel and to receive
10 signals from the calling unit and sent via an intermediary unit in a second frequency channel.

13. A communication unit according to any one of claims 6 to 12 and which is also operable as a calling unit.

15

14. A communication unit according to claim 13 and which as a calling unit is operable to send a signal which includes an address identifier of a target intermediary communication unit and a signal which includes an address
20 identifier of one or more target receiving communication units.

15. A communication unit according to claim 14 and wherein the said address identifiers are contained within
25 a common signal.

16. A communication unit according to any one of claims 6 to 15 and which is operable according to TETRA standard procedures.

30

17. A method of radio communication between a communication unit of a calling party and a communication unit of at least one receiving party, the method being characterised by the steps of:
- 5 receiving at the communication unit of the receiving party a radio call set-up request transmission from a communication unit of a calling party, wherein the call set-up request includes an indication that the call is to be or may be set-up via an intermediary communications
- 10 unit; and
- determining by the communication unit of the called party that a signal quality of a signal received directly from the communication unit of the calling party is or will be better than a signal quality of a re-transmitted
- 15 signal received via the intermediary communications unit; and
- participating by the communication unit of the called party in the call with the calling party directly.
- 20 18. A method according to claim 17, the method being further characterised by the step of:
- measuring a signal quality of the call set-up request transmitted by the calling party in order to determine that a call quality when participating in the call
- 25 directly with the calling party is acceptable.
19. A method according to claim 18 and which is further characterised by the steps carried out by the communication unit of the called party of:
- 30 monitoring of both a communication link of the call setup request and a communication link of a re-

transmitted call set-up request as transmitted by the intermediary communication unit;

measuring a signal quality of the re-transmitted call set-up request re-transmitted by the intermediary

5 communication unit; and

comparing the measured signal quality of a call set-up request transmitted by the communication unit of the calling party to the measured signal quality of the re-

10 transmitted call set-up request in order to determine whether to participate in the call directly with the calling party or via the intermediary unit.

20. A method according to any one of claims 17 to 19, and wherein the communication unit of the calling party is a
15 direct mode radio communication unit and the communication unit of the intermediary party is a radio communication repeater.

21. A method according to any one of claims 17 to 20 and
20 wherein the or each receiving communication unit receives signals from a calling communication unit directly in a first frequency channel and sent via an intermediary unit in a second frequency channel.

25 22. A method according to any one of claims 17 to 21 and wherein the calling unit sends a signal which includes an address identifier of at least one target intermediary communication unit and a signal which includes an address
30 identifier of at least one target receiving communication unit.

23. A method according to any one of claims 17 to 22
claim 14 and wherein the said address identifiers are
contained within a common signal.

5 24. A method according to any one of claims 17 to 23 and
which operates according to TETRA standard procedures.

25. A method according to any one of claims 17 to 24 and
which comprises a method of call set-up between two or
10 more communication units of users who are to participate
in a call together.

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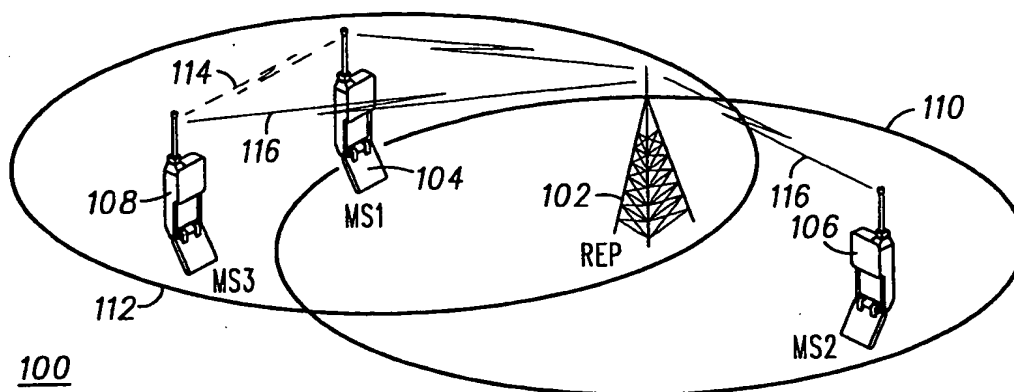


FIG. 1

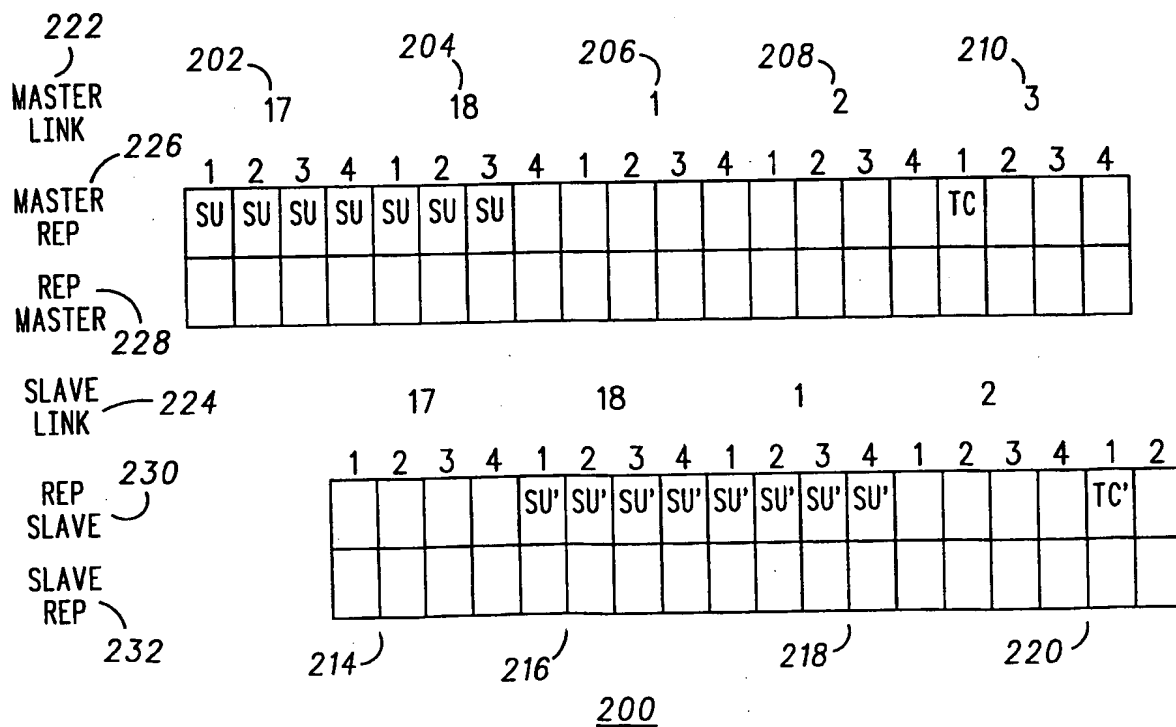


FIG. 2

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FIG. 3

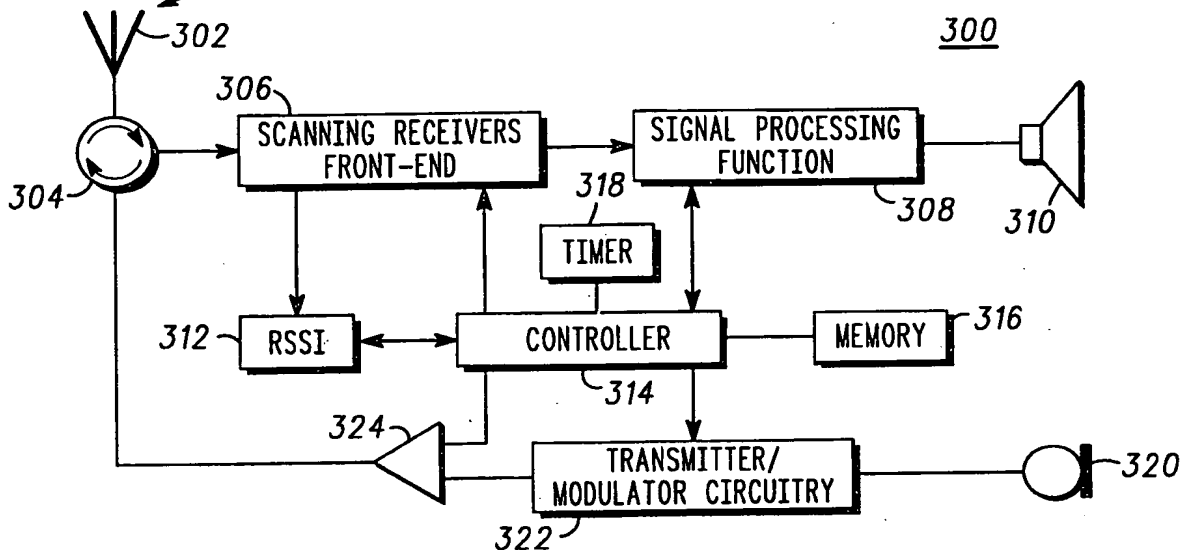
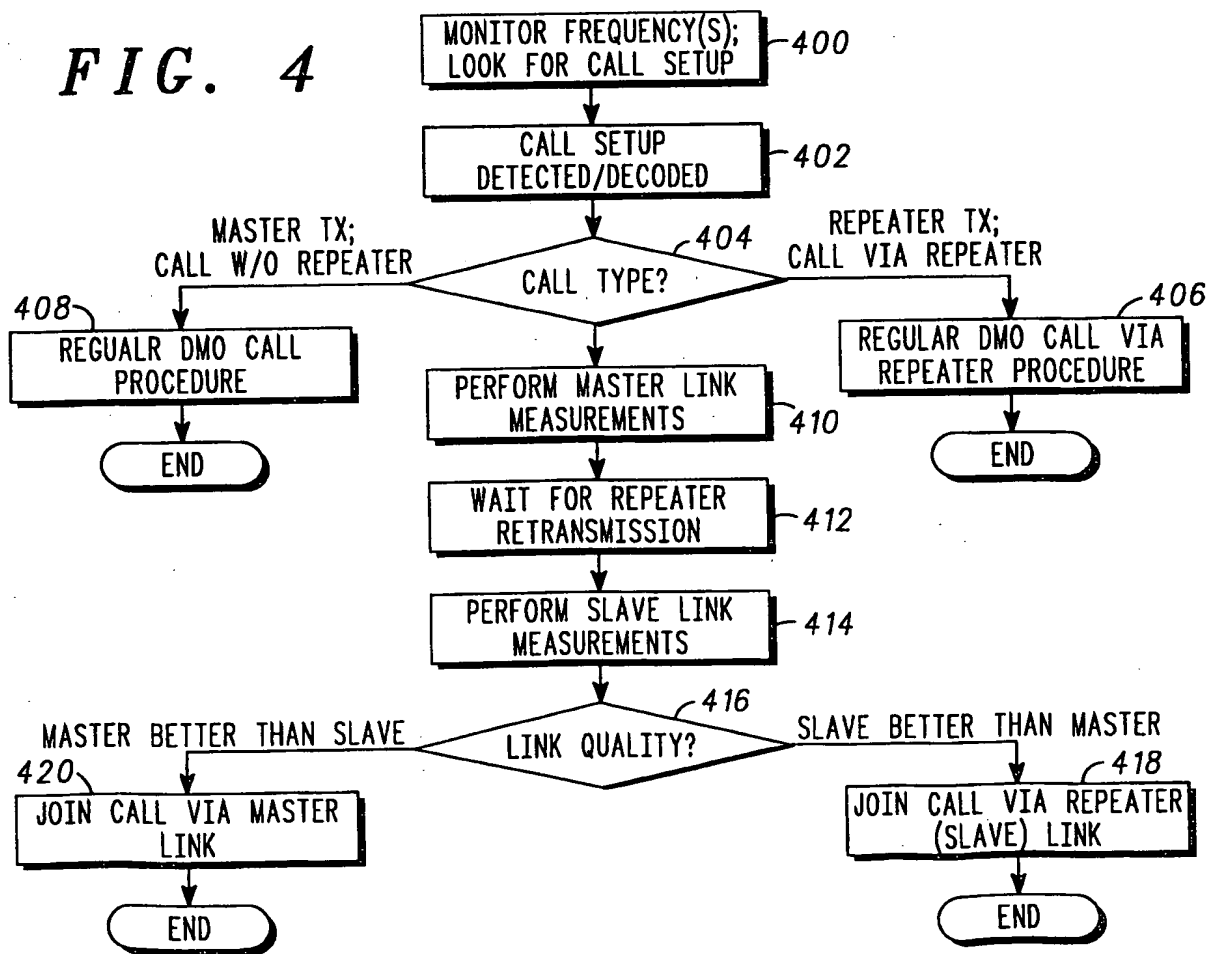


FIG. 4



INTERNATIONAL SEARCH REPORT

Inte. No. 01/2046
PCT/EP

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q H04B H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 316 271 A (MOTOROLA LTD) 18 February 1998 (1998-02-18) page 3, line 4 -page 8, line 18	1,2,4-7, 9-13, 16-18, 20-24
Y	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) -& JP 07 023464 A (MITSUBISHI ELECTRIC CORP), 24 January 1995 (1995-01-24) abstract	1,2,4-7, 9-13, 16-18, 20-24
E	EP 1 168 676 A (MATSUSHITA ELECTRIC IND CO LTD) 2 January 2002 (2002-01-02) column 3, line 46 -column 7, line 54	1-10,13, 17-20
P,X	-& WO 01 61887 A (MATSUSHITA ELECTRIC IND CO LTD (JP)) 23 August 2001 (2001-08-23)	1-10,13, 17-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

8 March 2002

Date of mailing of the international search report

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Information on patent family members

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tion No

PCT/EP 01/12046

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2316271	A	18-02-1998	AU 3770497 A WO 9806228 A2 EP 0853861 A2 GB 2356532 A ,B GB 2356322 A ,B	25-02-1998 12-02-1998 22-07-1998 23-05-2001 16-05-2001
JP 07023464	A	24-01-1995	JP 2921341 B2	19-07-1999
EP 1168676	A	02-01-2002	JP 2001230723 A AU 3231701 A EP 1168676 A1 WO 0161887 A1	24-08-2001 27-08-2001 02-01-2002 23-08-2001